Search for the decay $B_{s(d)}$--> eμ in RUN II

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Outline

- Motivation,Theory, results from Run I and our competition (CLEO, BELLE).
- Strategy for Run-II measurement
- Normalization mode
- Bs->e μ reconstruction
- Choice of background sample(s)
- Signal optimization
- Acceptance calculation
- Expectation

Theory(I)

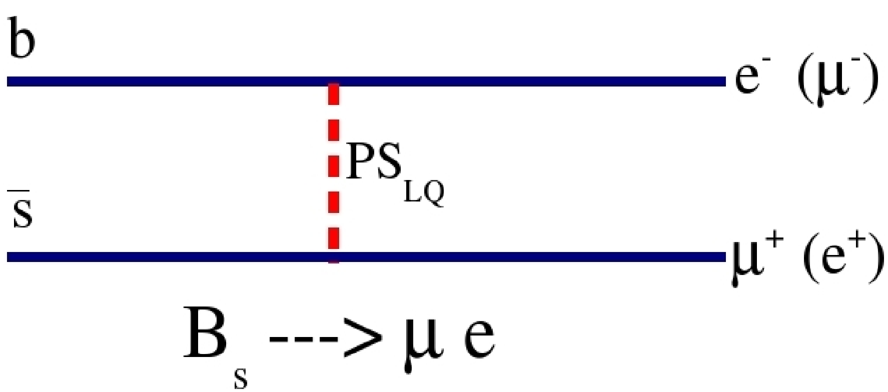
Within the Standard Model the decays B_s--> eμ and B_d--> eμ are forbidden by lepton flavor conservation; observation of either of these decays would be evidence for new physics.

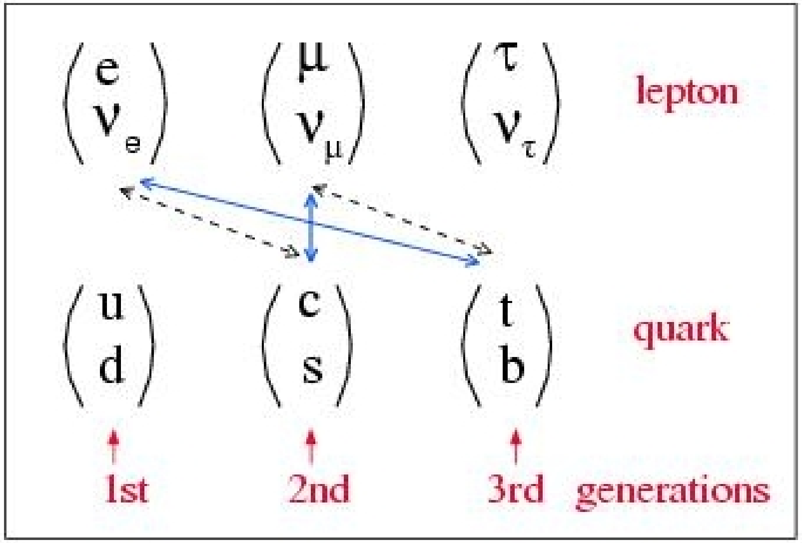
In particular the assumption of a local gauge symmetry between quarks and leptons leads to the prediction of a new force of nature that mediates transitions between quarks and leptons.
One of the simplest models that incorporates this idea is the Pati-Salam model based on the group $SU(4)_c$ where the lepton number is the fourth "color." (Physical Review D 10, 1974)

At some high-energy scale, the group $SU(4)_c$ is spontaneously broken to $SU(3)_c$, liberating the leptons from the influence of the strong interaction and breaking the symmetry between quarks and leptons.

Theory(II)

This model predicts heavy spin-one gauge bosons called Pati-Salam leptoquarks PS_{LQ} that carry both color and lepton quantum numbers.



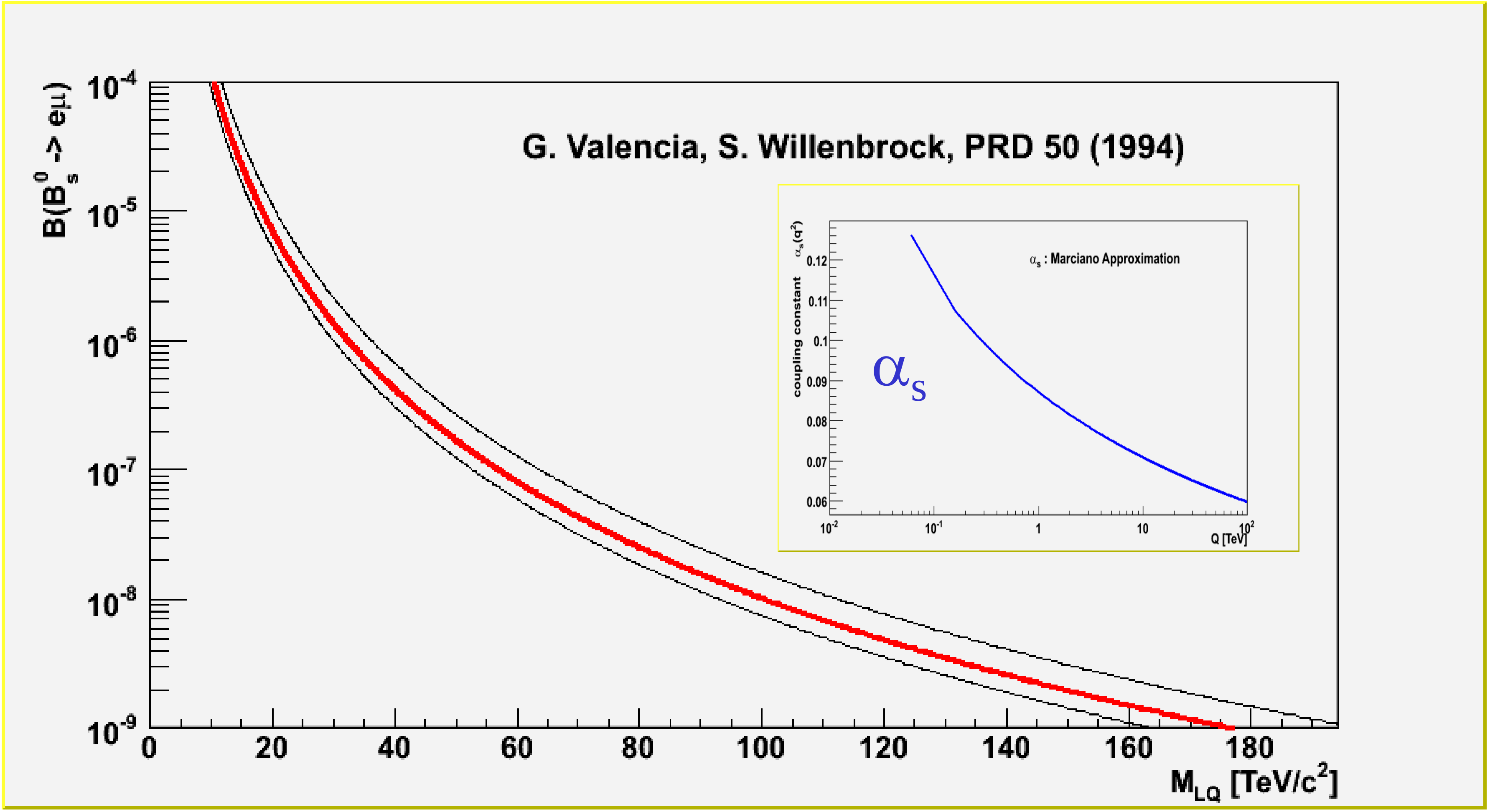


Note! The Pati Salam model:

- allows for cross-generation couplings,
- leads to violation of baryon (B) and lepton (L) number, though fermion number F=B+L is still conserved

Theory(III)

PS_{LQ} interact strongly with the coupling constant $\alpha_s(Q^2)$ extrapolated to $Q^2 = M_{LQ}^2$



Run I measurement

Absolute measurement!

Dataset: e μ Trigger: $P_T(\mu)$ >3 GeV/c , $E_T(e)$ > 5 GeV

MC:

- Acceptance
- cτ cut
- Pointing Angle

Data/Control samples:

- Trigger efficiency
- Isolation, Pointing Angle
- Lepton ID cuts

Requirement	Efficiency in %
Geometric and kinematic acceptance for $p_T(B) > 6$ GeV$/c$ and rapidity $\|y(B)\| < 1$	2.27 ± 0.024
Trigger efficiency	37.2 ± 1.6
Reconstruction of two tracks in CTC	89.8 ± 3.6
Muon selection criteria	99.5 ± 0.1
Electron selection criteria	84.8 ± 1.1
Track and vertex quality selection criteria	68.3 ± 3.1
Proper decay length ($\lambda > 100\mu m$)	81.0 ± 0.8
Pointing angle ($\Delta\varphi < 0.1$)	85.2 ± 2.3
Isolation ($I > 0.7$)	85.1 ± 3.0
Mass window	98.0 ± 0.6
Total efficiency × acceptance (ϵ_{tot})	0.252 ± 0.022

$$\boxed{2\cdot\sigma(B)\cdot\mathcal{B}(B \to e^{\pm}\mu^{\mp}) < \frac{N^l(B\to e^{\pm}\mu^{\mp})}{\int \mathcal{L}dt\cdot\epsilon_{tot}}.}$$

Run I, Belle and CLEO

In Run I with 102 pb^{-1}, published in PRL(81) 1998,
@ 90 (95) % C.L. we obtained:

$$\mathcal{B}(B_s^0 \to e^\pm\mu^\mp) < 6.1(8.2) \times 10^{-6}$$
$$\mathcal{B}(B_d^0 \to e^\pm\mu^\mp) < 3.5(4.5) \times 10^{-6}$$

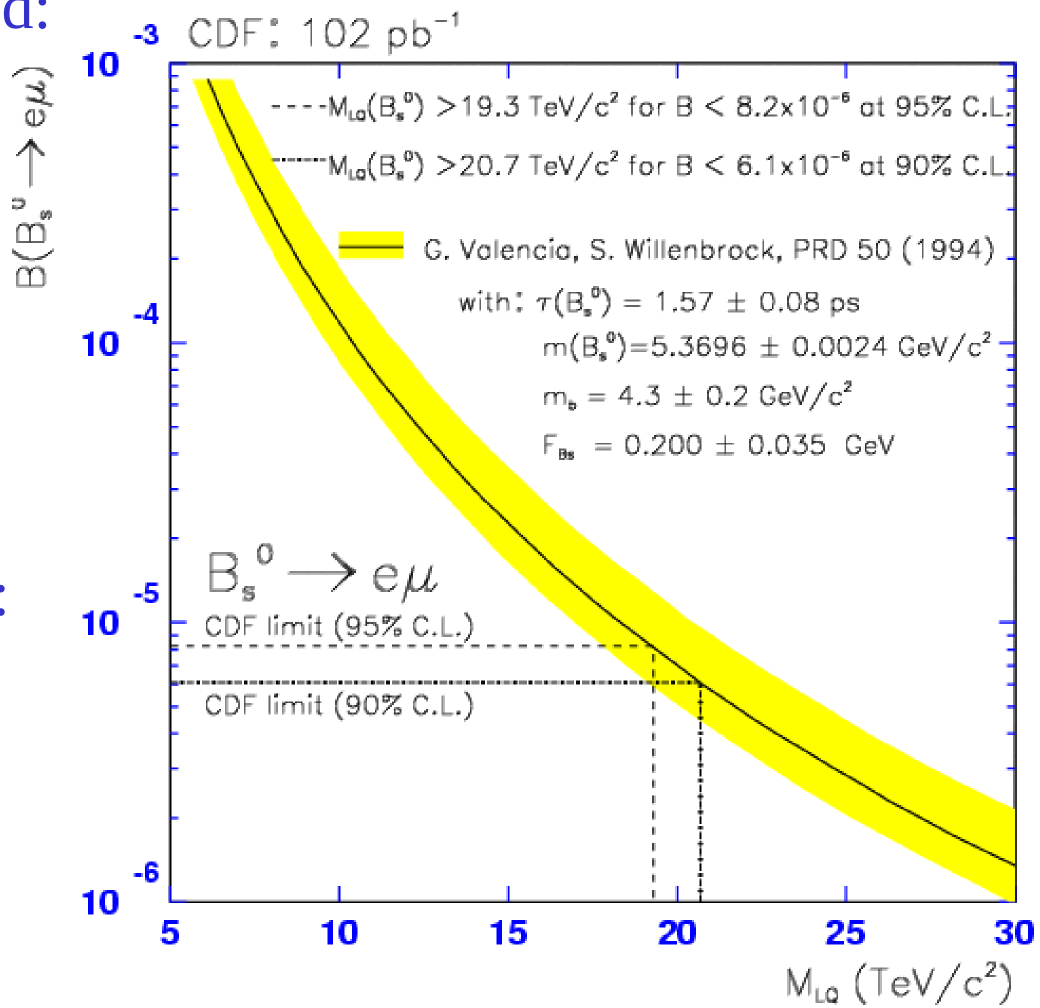
Which corresponds to:

$$\mathrm{M_{LQ}}(B_s^0) > 20.7(19.3)\ \mathrm{TeV}/c^2$$
$$\mathrm{M_{LQ}}(B_d^0) > 21.7(20.4)\ \mathrm{TeV}/c^2$$

Our competition @ 90% C.L.:

$$\mathcal{B}(B_d^0 \to e^\pm\mu^\mp) < 1.7\times10^{-7}\ (\mathrm{BELLE})$$

$$\mathcal{B}(B_d^0 \to e^\pm\mu^\mp) < 1.5\times10^{-6}\ (\mathrm{CLEO2})$$



Run II measurement

- Relative Measurement!
- Dataset: Two Track SVT Trigger
- Require tracks to match tracks identified by SVT
- Require tracks to be identified as e or μ, assign mass to tracks accordingly
- Use the B→ 2 hadrons channel as reference mode, many efficiencies and uncertainties cancel.
- Set a limit:

  http://www-cdf.fnal.gov/physics/statistics/statistics_home.html

  CDF Node 6428

$$\mathcal{B}(B \to e^{\pm}\mu^{\mp}) < \frac{N^{l}(B \to e^{\pm}\mu^{\mp}) \cdot \mathcal{B}(B \to h^{+}h^{-})}{\epsilon_{rel} \cdot N(B \to h^{+}h^{-})}$$

Track and B-Meson selection

the B->hh analysis CMS node 7066,

Require good run list,

Data set: xbpp0d,

offline version 6.1.1.

Luminosity: 360 pB^{-1}

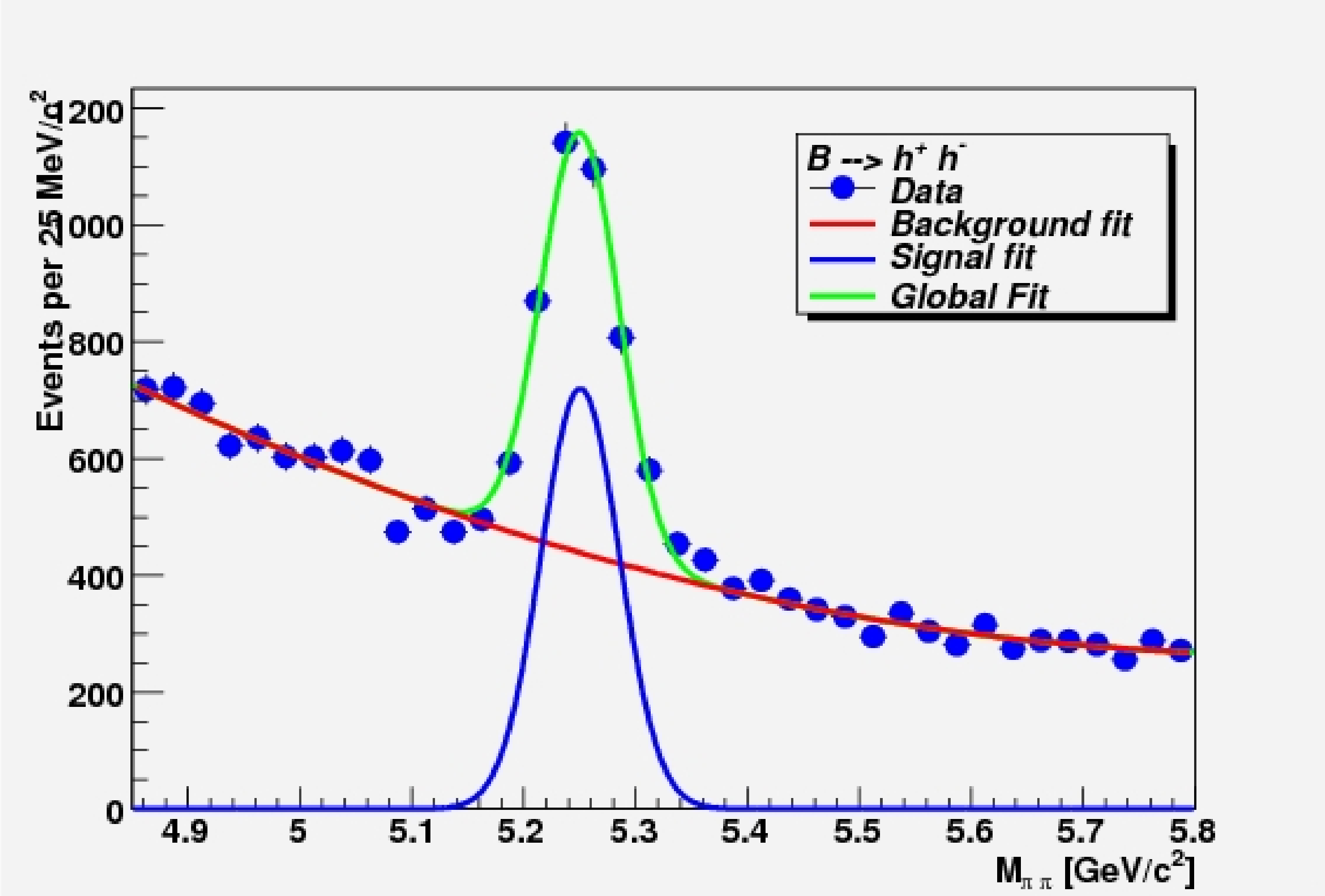
Track selection:	
# axial COT Hits	≥ 20
# stereo COT Hits	≥ 16
# $r - \varphi$ SVXII Hits	≥ 3
$\|\eta\|$	≤ 1
p_T	$\geq 2GeV/c$
$p_T(1) + p_T(2)$	$\geq 5.5GeV/c$
$q(1) \times q(2)$	< 0
$\Delta\phi$	$22^0 < \Delta\phi < 150^0$
$\|d_0\|$	$140\mu m < \|d_0\| < 1mm$
$d_0(1) * d_0(2)$	< 0
B-candidate selection:	
invariant mass	$4.6 < M(B) < 6.$
$\|\eta\|(B)$	≤ 1
$\|d_0\|(B)$	$\leq 80\mu m$
Δz	$\|z_0(1) - z_0(2)\| \leq 5cm$
L_{xy}	$\geq 300\mu m$

Track and B-Meson selection

of Events: 2520+/- 88

Peak: 5.251 GeV/c^2

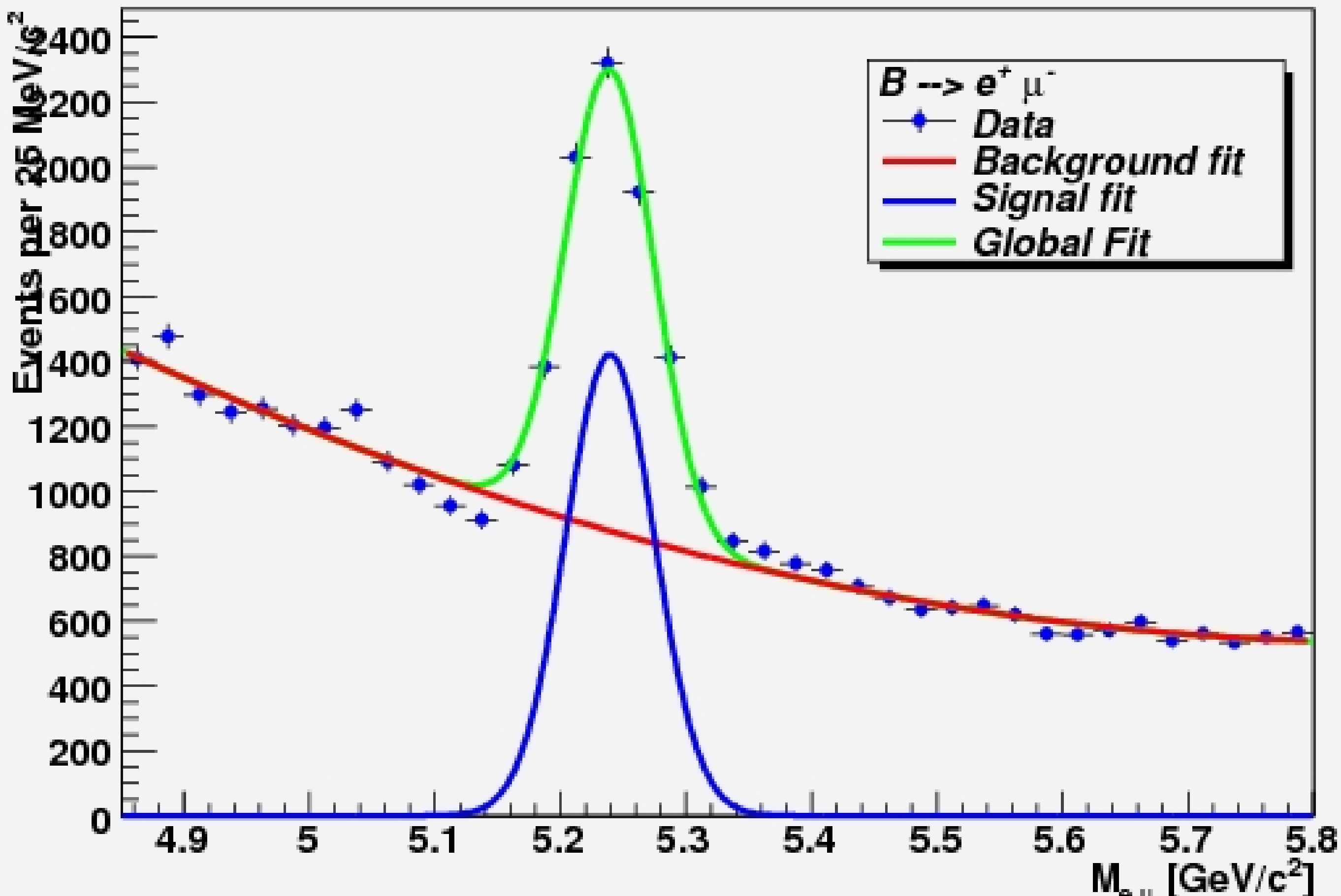
σ_M: 35MeV/c^2



Track and B-Meson selection

Peak: 5.240 GeV/c^2

σ_M: 35 MeV/c^2

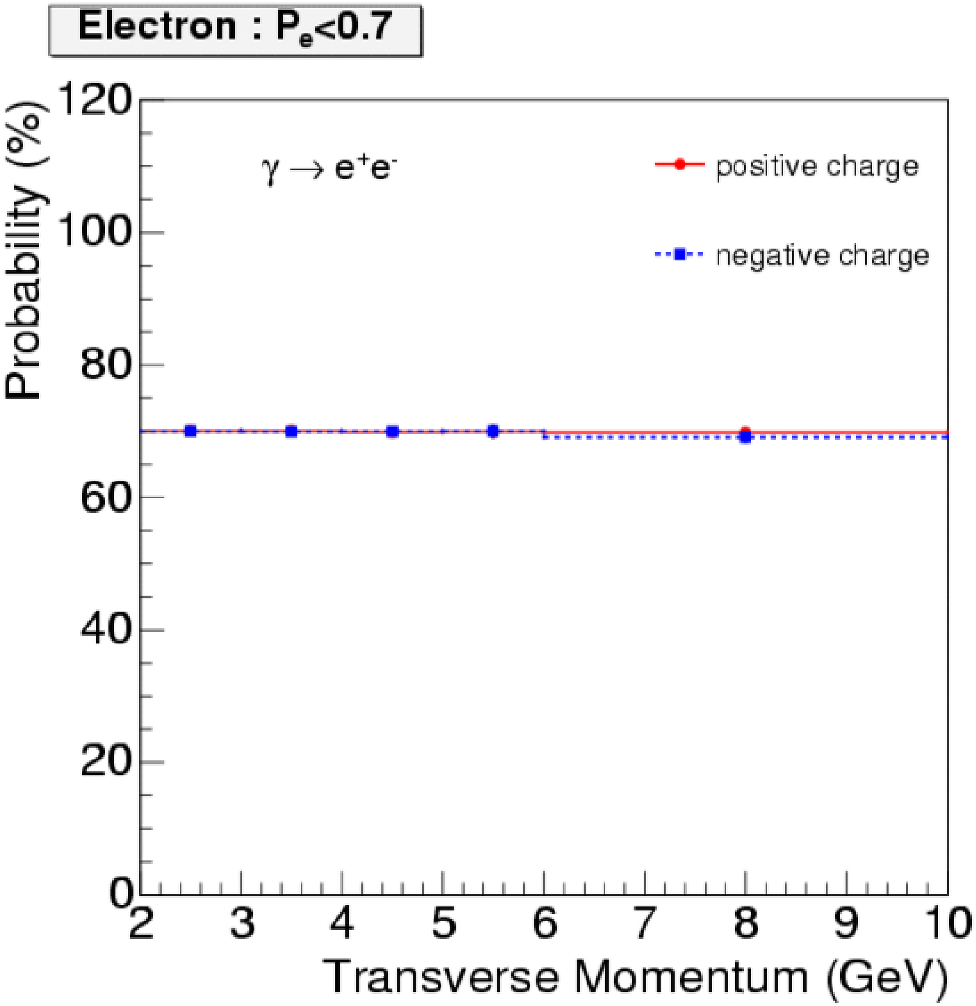


Relative efficiencies

- Electron Acceptance + selection Efficiencies
- Losses out of the mass window due to Bremsstrahlung, Trigger efficiencies?
- μ Acceptance + selection Efficiencies
- Efficiencies of additional selection requirement to optimize S^2/Bgr: Isolation, $\Delta\phi$, $c\tau$, p_T

electron Identification

- Track based Electron ID described in CDF node 7518



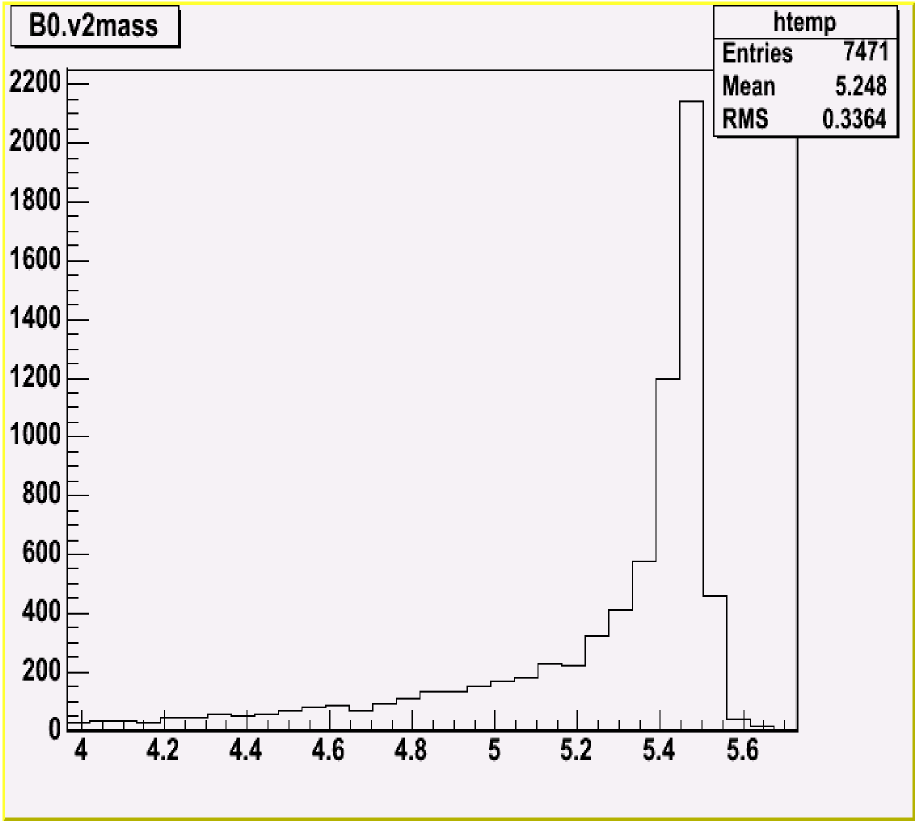
CEM/CES fiducial coverage: 0.802+/-0.015

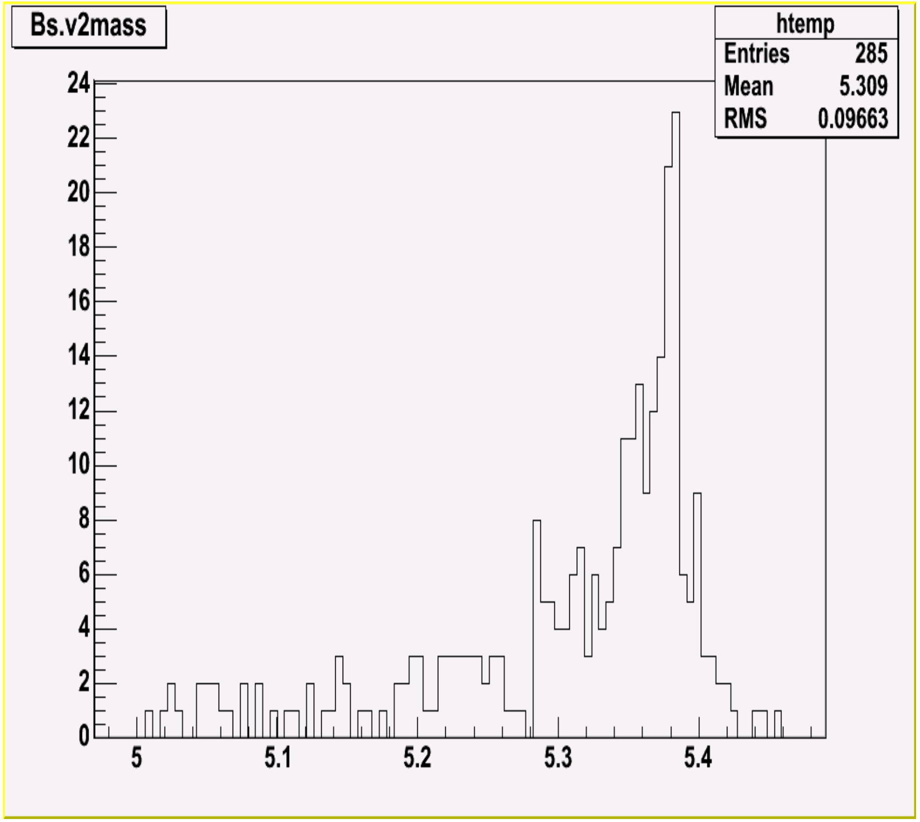
ε(ele) ~ 70 %

μ Identification

- CMU+CMX fiducial coverage: 0.396+0.283=0.679 (Run-II TDR)
- Muon ID efficiency:
  - CMU chi2 (r-phi)<9
    eff=99.56+0.03% (CDF note 6114).
  - CMX chi2(r-phi)<9
    eff=99.13+-0.05%(CDF 6835).

Bremsstrahlungs losses (from MC)



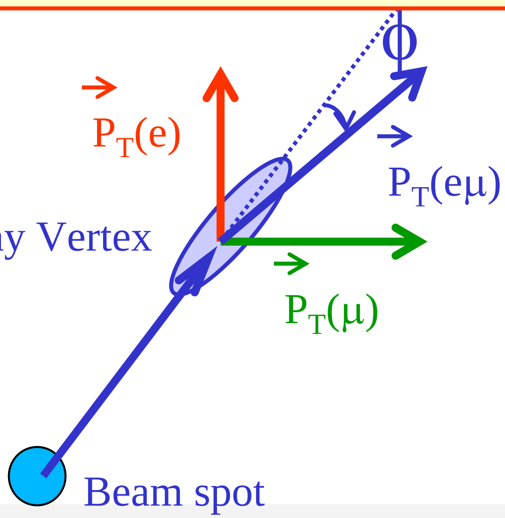


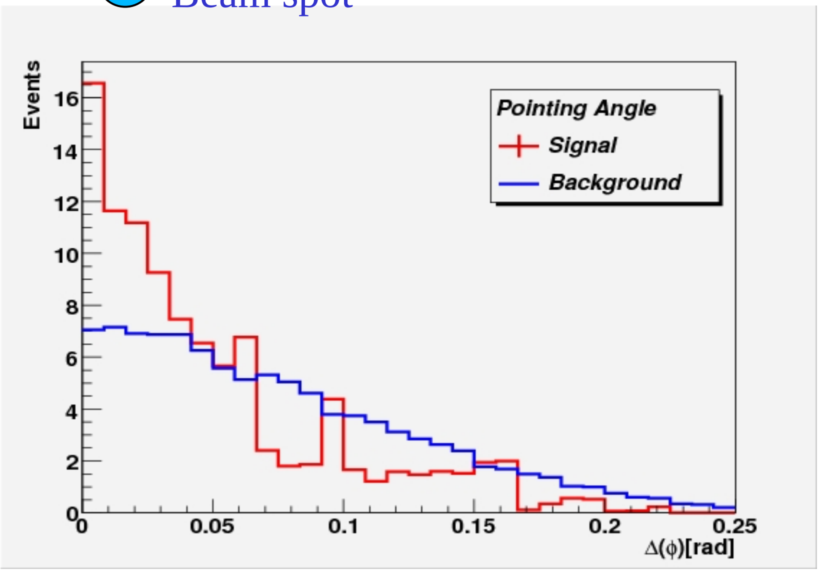
PT(B)>2GeV/c

PT(B)>5GeV/c

Optimization of selection Criteria

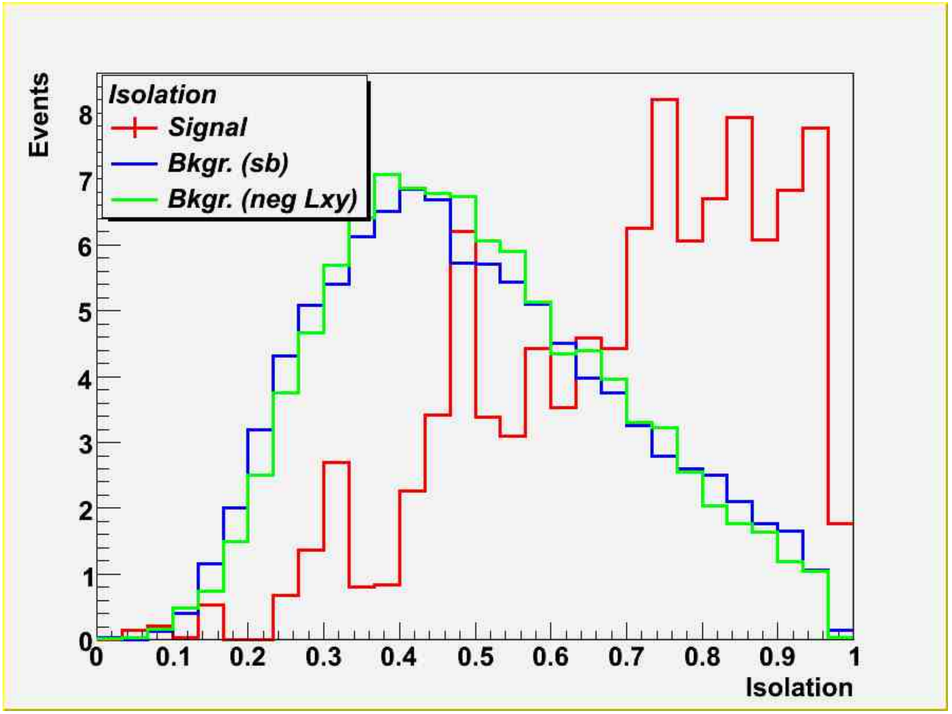
Pointing Angle Δϕ:





Track based Isolation:

$$I = \frac{p_T(e\mu)}{p_T(e\mu) + \Sigma\, p_T}$$



Optimization of selection criteria

Maximize Figure of Merit: FOM=ε^2 x Rej

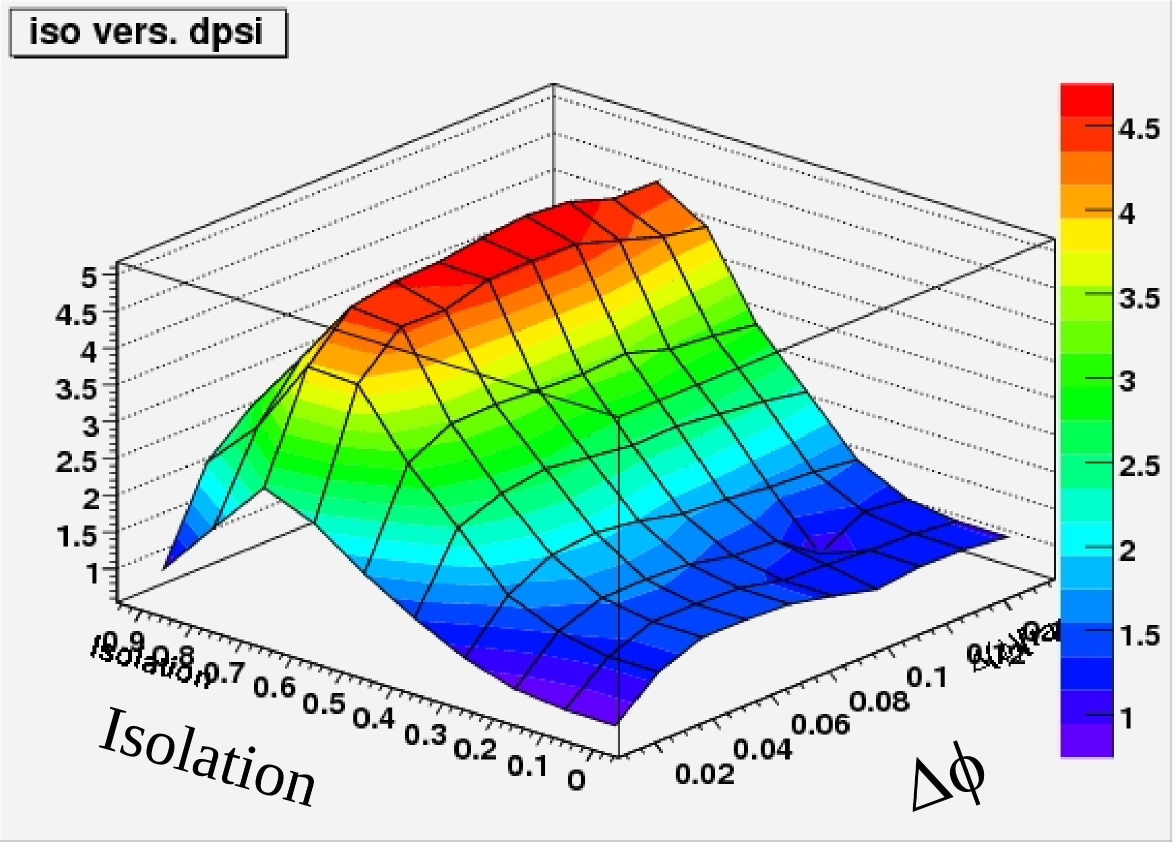
ε : # Signal Events after cuts /#Signal events before cut

Rej: # Bgr. Events before cuts /# Bgr. events after cuts

The number of Signal and the number of Bgr. Events from a fit to the entire B->hh invariant mass spectrum.

Optimum:

$\Delta\phi$ < 0.1 rad
Iso > 0.7
ε = 65%
Rej = 11.3



Expectation with current data

- B_d :
  Assume 60% ->Kπ in sample,
  $Br(B_d \to K\pi) = 1.85 \times 10^{-5}$
  Assume: 0 Events -> 2.3 @ 90%C.L.
  $Br(B_d \to e\mu) > 1.2 \times 10^{-7}$
- B_s :
  Assume 26% ->KK in sample,
  $Br(B_s \to KK) = 3.1 \times 10^{-5}$
  Assume: 0 Events -> 2.3 @ 90%C.L.
  $Br(B_d \to e\mu) > 4.6 \times 10^{-7}$

No systematics, ….

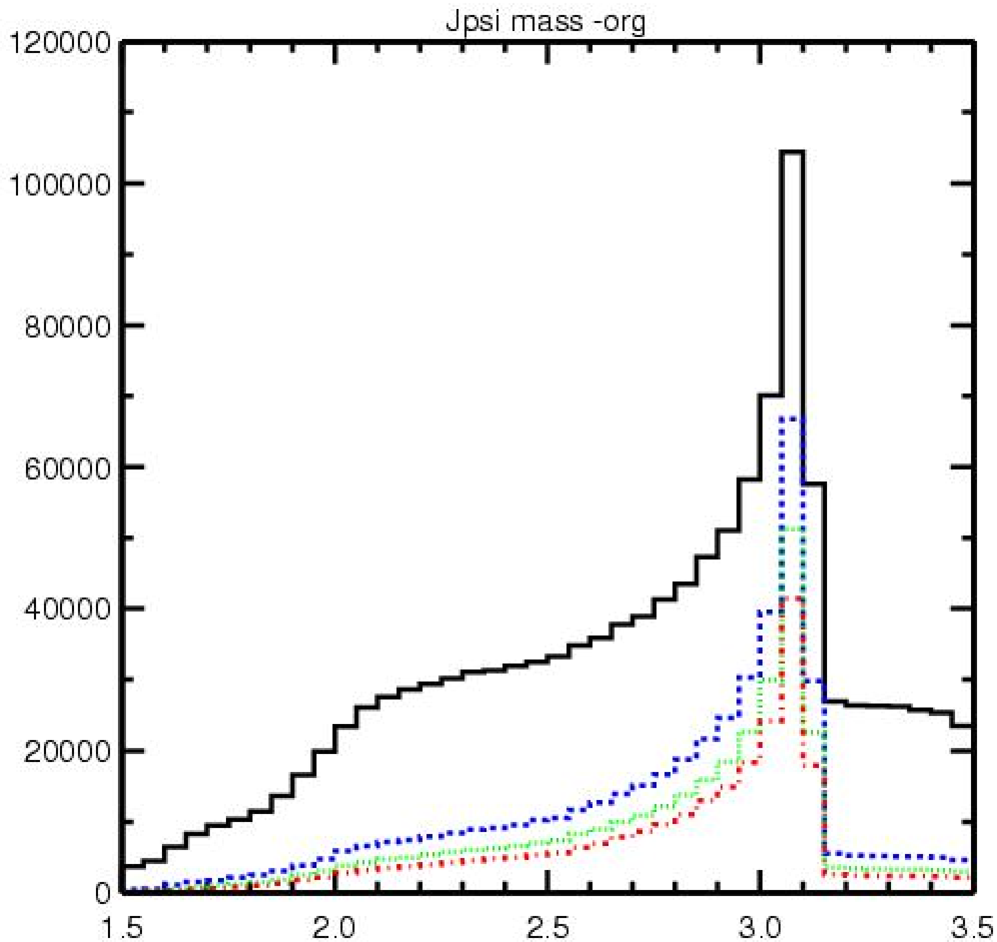
Plan

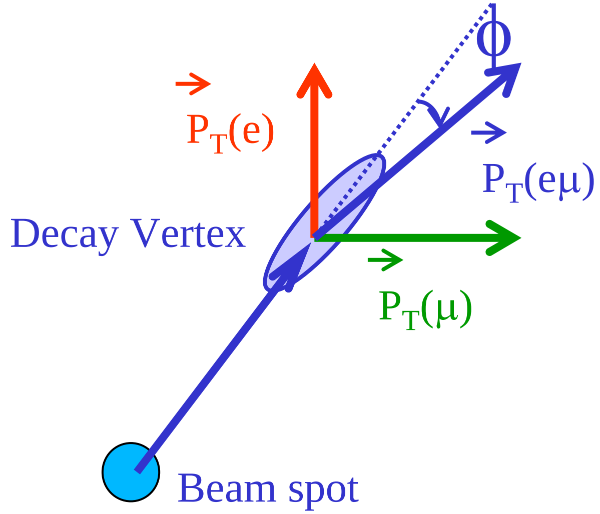
- Check and double check.
- Produce MC sample for various checks.
- Get procedure in place to extract limit including systematics.
- Plan to get final result with $1fb^{-1}$ of data.

Backup Slides

File: ee.hbook

ID	IDB	Symb	Date/Time	Area	Mean	R.M.S.
1	0	1	051006/0956	1.2307E+06	2.708	0.4595
2	0	2	051006/0956	4.5038E+05	2.781	0.3884
3	0	3	051006/0956	3.2282E+05	2.797	0.3720
4	0	4	051006/0956	2.5197E+05	2.808	0.3599




$\vec{P}_T(e)$
φ
$\vec{P}_T(e\mu)$
Decay Vertex
$\vec{P}_T(\mu)$
Beam spot